User Guide for

GreenBridge™ Evaluation Kit for Power Over Ethernet 90 W Active Clamp Forward DC-DC Converter

MLP 4.5x5 GreenBridge™

Power 33/56 Shielded Gate PowerTrench® MOSFET

Featured Fairchild Products:

FDMQ8203

FDMS86200

FDMS8025S

FDMC2523P

Direct questions or comments about this evaluation board to: "Worldwide Direct Support"

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This user guide supports the evaluation kit for GreenBridge™ and shielded gate PowerTrench® MOSFET applying to a Power Device (PD) of Power over Ethernet (PoE). It should be used in conjunction with their datasheets as well as Fairchild's application notes and technical support team. Please visit Fairchild's website at www.fairchildsemi.com.

1. Introduction

This document describes the proposed solution for PoE++ PD that increases the delivering power up to 90 W. It is designed to rectify a polarity of DC voltage from Power Source Equipment (PSE) and then active clamp forward DC-DC converter steps down a nominal input voltage 48 V_{IN} to output voltage 3.3 V_{OUT} in 300 kHz of the switching frequency. To deliver 90 W power through a network cable, the power system is composed with four-pair architecture, which PSE uses to deliver data and power to the PD through both the spare pair and data pair in the network cable at the same time.

1.1. Description

GreenBridge™ FDMQ8203 replaces the conventional diode bridge to reduce the power dissipation caused by the large voltage drop of a diode bridge, resulting in a lower power class power device. The small package size of MLP4.5x5 reduces PCB area and increases power density. FDMC86102 100 V shielded gate PowerTrench® MOSFET for the hot swap switch has the low conduction loss and the ruggedness due to the low $R_{DS(on)}$ and wide safe operating area (SOA). The FDMS86200 150 V shielded gate PowerTrench MOSFET reduces switching loss and conduction loss in the primary switch of the active clamp forward topology because it has low FOM ($R_{DS(on)}$ x Qg). The FDMS8025S 30 V shielded gate PowerTrench MOSFET is optimized for synchronous rectification because it has the low $R_{DS(on)}$ and outstanding body diode performance.

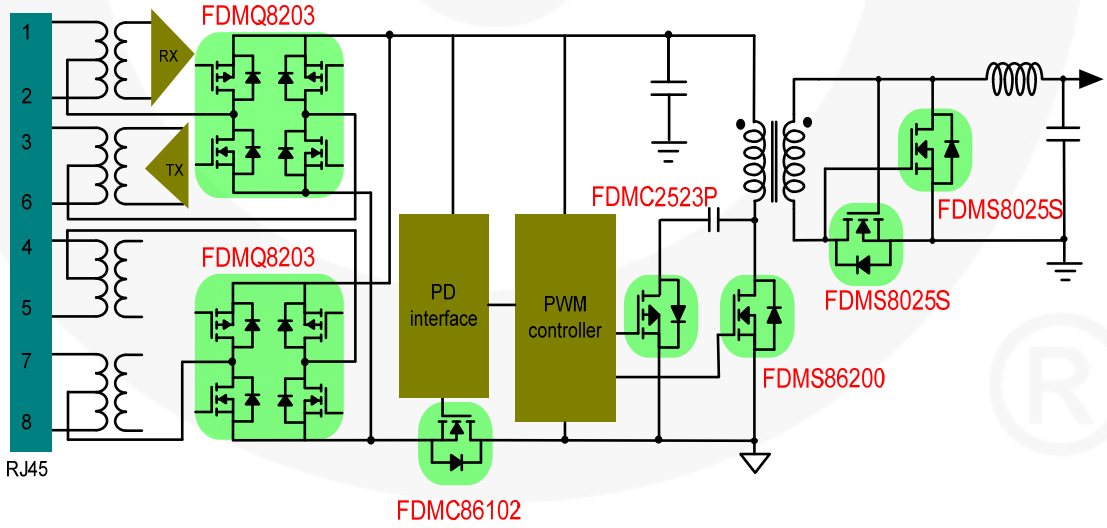


Figure 1. Power diagram

Table 1. MOSFET Parameters

Part Number	Package	Type	BV_{DSS}(V)	$R_{DS(ON)}$ [mΩ] at 10 V_{GS}	Qg [nC] at 10 V_{GS}	C_{OSS} [pF]
				Max.	Max.	Max.
FDMQ8203	MLP 4.5x5	N-Ch	100	110	5	55
		P-Ch	-80	190	19	65
FDMC86102	POWER33	N-Ch	100	24	13	175
FDMS86200	POWER56	N-Ch	150	18	33	203
FDMC2523P	POWER33	P-Ch	-150	1500	9	80
FDMS8025S	POWER56	N-Ch	30	2.8	34	815

2. General Evaluation Board Specifications

Table 2. Summary of Features and Performance

Description		Value	Remark
Input Voltage Range		42 ~ 57 V_{IN}	IEEE802.3 at Standard
Output Voltage Range		3.3 V_{OUT}	Adjustable by R22 and R46
Switching Frequency		300 kHz	Adjustable by R29 and R30, R31
Maximum Output Current		27 A	Limited by Power Component
PCB Size		100x70 mm	FR-4 / 4 Layers
PD Controller		IEEE802.3 at PD Controller	
PWM Controller		Active Clamp Forward Controller	
Efficiency	42V_{IN}	>89%	At Full Load (90 W)
	48V_{IN}	>90%	
	57V_{IN}	>90%	
Temperature	FDMQ8203	58.4°C	At Full Load (25℃ Room Temperature)
	FDMC86102	56.4°C	
	FDMS86200	74°C	
	FDMC2523P	65°C	
	FDMS8025S	88.6°C	

3. Photographs

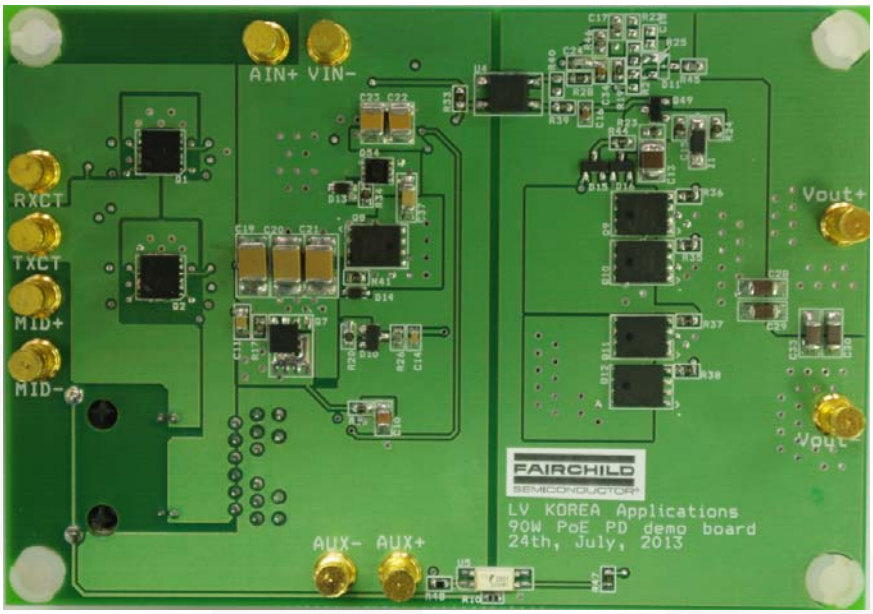


Figure 2. Top Side View of Evaluation Kit

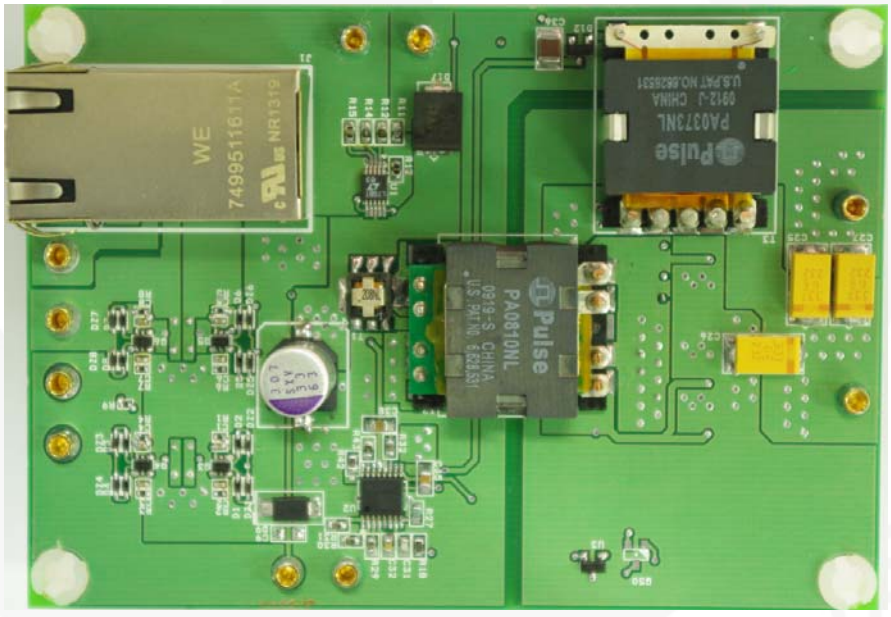


Figure 3. Bottom Side View of Evaluation Kit

4. Setup and Test Procedure

Table 3. Test Point Descriptions

Test Point	Label	Descriptions
J6	AUX+	Measurement test point for positive AUX input voltage
J7	AUX-	Measurement test point for negative AUX input voltage
J8	VIN+	Measurement test point for rectified positive input voltage
J9	VIN-	Measurement test point for input voltage return
J10	+VOUT	Measurement test point for output voltage
J11	-VOUT	Measurement test point for output voltage return

4.1. Hardware Connector Description

The evaluation kit is fully assembled and tested. Follow the steps below to verify board operation.

1. Use one of the following methods to power the evaluation kit:
   - If network connectivity is required:
     Connect a network cable from the evaluation kit input port RJ45 connector to the corresponding PSE Ethernet LAN connection, which provides power to the evaluation kit such as PoE++ or four-fair architecture.
   - If network connectivity is not required:
     Connect a -48 V DC power supply between the TXCT and RXCT; and
     Connect a -48 V DC power supply between the MID+ and MID- together.

Caution: Do not turn on the power supply until all connections are completed.

2. Activate the PSE power supply or turn on the external DC power supply.
3. Using a voltmeter, verify that the evaluation kit provides +3.3 V across the +VOUT and –VOUT pins. –VOUT is isolated from the evaluation kit's input VIN- and AUX- pins.

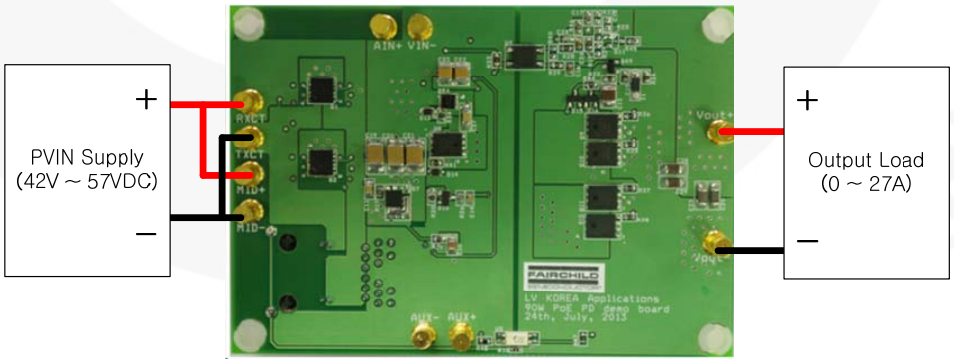


Figure 4. Test Setup

5. Performance of Evaluation Board

Figure 5 through Figure 9 show the measured efficiency and power loss on the evaluation board when operated under the conditions in Table 4. This board is optimized for 3.3 V_{OUT}, 300 kHz f_{SW}, and peak 27 A I_{OUT} specifications.

Table 4. Test Conditions

V_{IN}	V_{OUT}	f_{SW}	I_{OUT}	Cooling
42 ~ 57 V	3.3 V	300 kHz	0~27 A, 5 A Step, 3-minute soak time	No

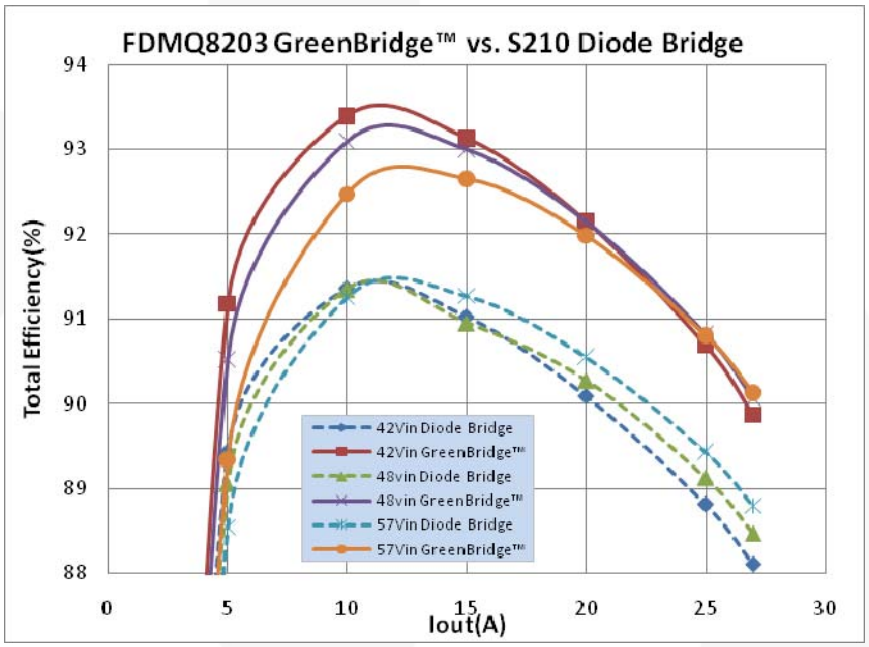


Figure 5. Efficiency at V_{OUT}=3.3 V, f_{SW}=300 kHz, Soaking=3 Minutes, T_A=25°C

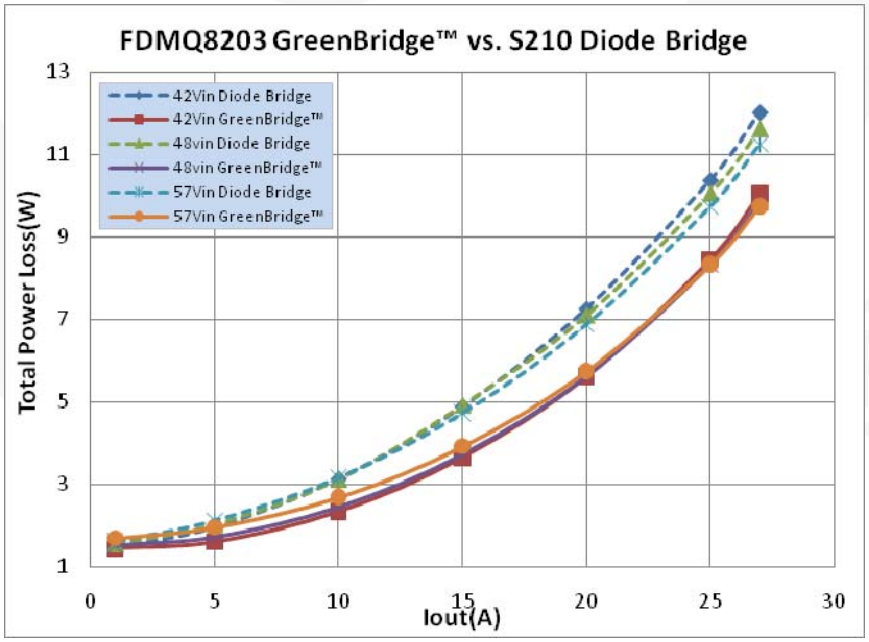
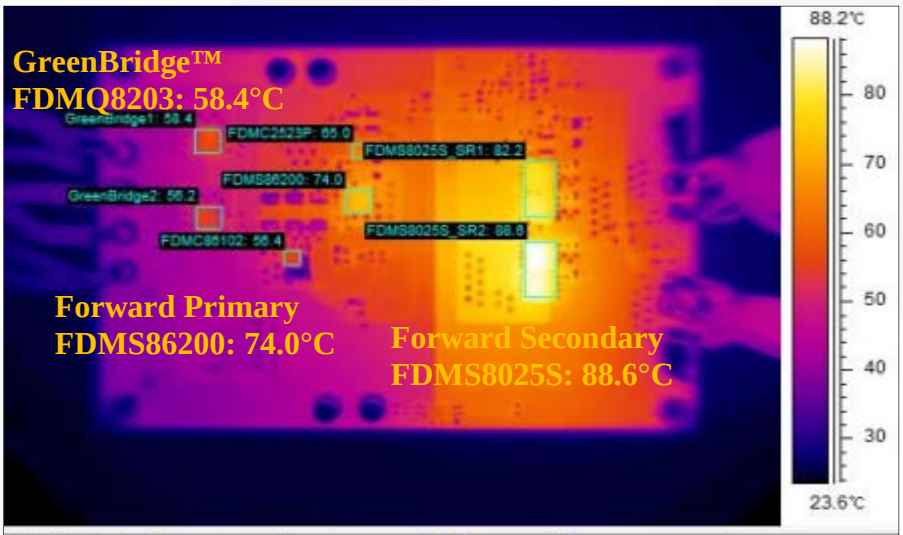


Figure 6. Power Loss at V_{OUT}=3.3 V, f_{SW}=300 kHz, Soaking=3 Minutes, T_A=25°C

Figure 7. Thermal Performance Comparison: GreenBridge™ vs. Diode Bridge at V_{OUT}=3.3, f_{SW}= 300 kHz, Soaking=3 Minutes, T_A=25°C



Analysis | Position | Obj. Par | Image | Text comment

Label	Value [℃]	Min	Max	Max - Min	Avg	Stdev	Res
Image		23.4	88.6	65.2			
GreenBridge1		50.8	58.4	7.6	55.5	1.7	
GreenBridge2		45.9	56.2	10.4	53.6	2.0	
FDMC2523P		54.1	65.0	10.9	62.1	3.3	
FDMS86200		66.4	74.0	7.6	71.8	1.8	
FDMC86102		50.4	56.4	6.0	55.1	1.4	
FDMS8025S_SR1		63.1	82.2	19.1	77.9	3.3	
FDMS8025S_SR2		68.4	88.6	20.1	84.4	3.5	

Figure 8. Top-Side Thermal Data at V_{IN}=48 V, V_{OUT}=3.3 / I_{OUT}= 27 A, f_{SW}= 300 kHz, Soaking=10 Minutes, T_A=25°C

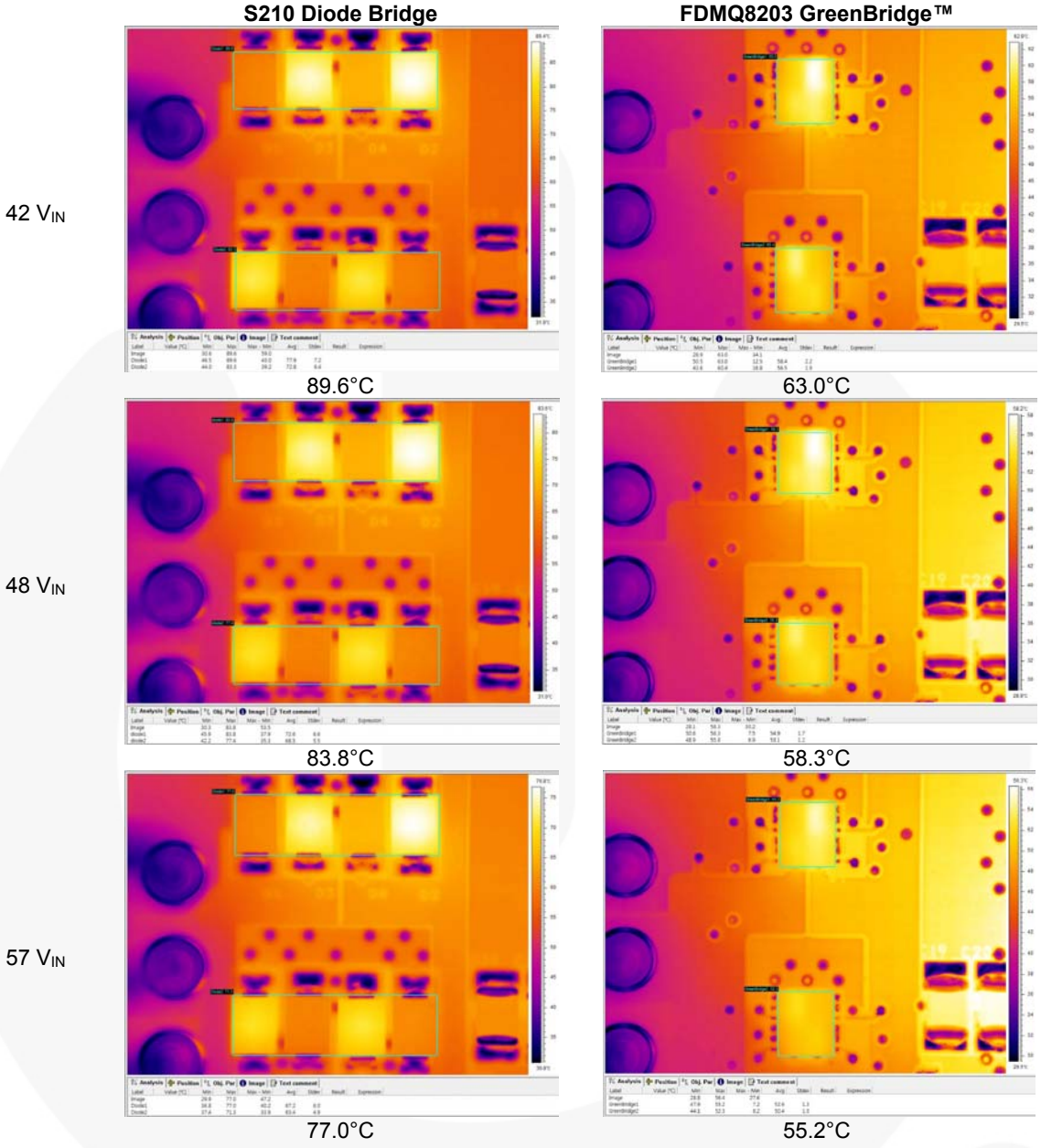


Figure 9. Thermal Image Comparison: GreenBridge™ vs. Diode Bridge
V_{OUT}=3.3 V, I_{OUT}= 27 A, f_{SW}=300 kHz, Soaking=3 Minutes, T_A=25°C

6. Printed Circuit Board

PCB layout (100 mm x 70 mm, 4-Layer, FR-4).

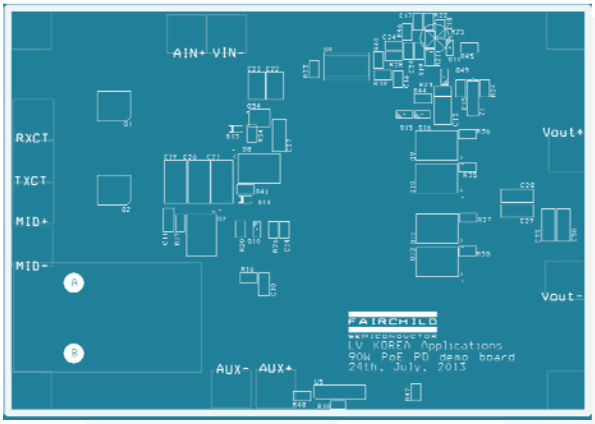


Figure 10. SST (Top Side) Layer

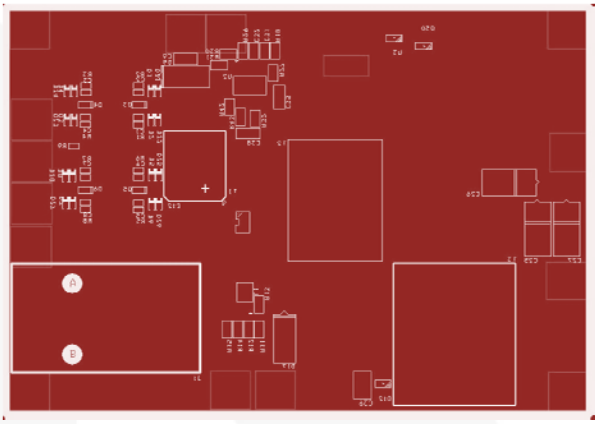


Figure 11. SSB (Bottom Side) Layer

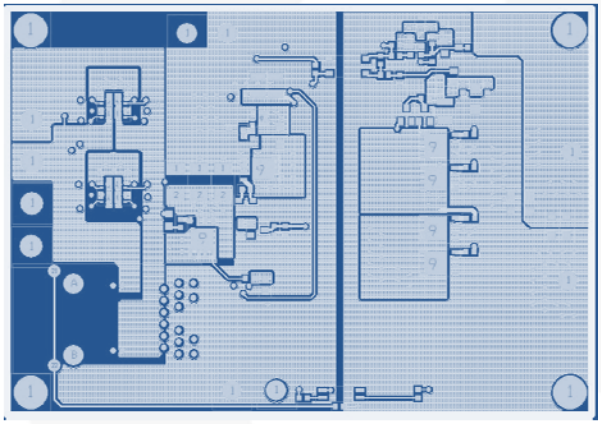


Figure 12. TOP & SMT Layer

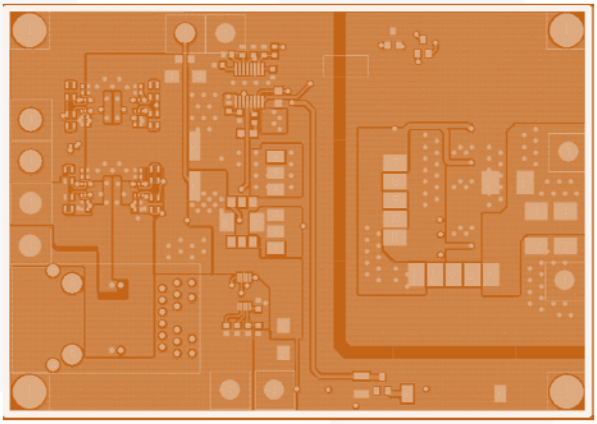


Figure 13. BOT & SMB Layer

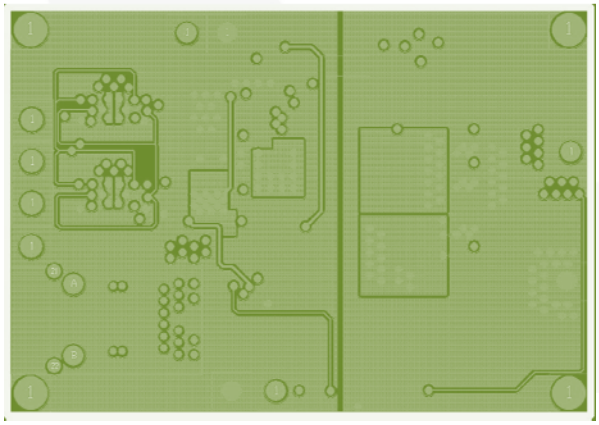


Figure 14. INNER1 (POWER) Layer

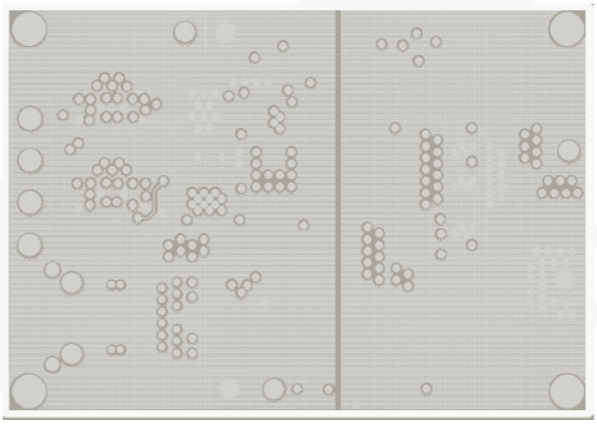


Figure 15. INNER2 (GND) Layer

7. Schematic

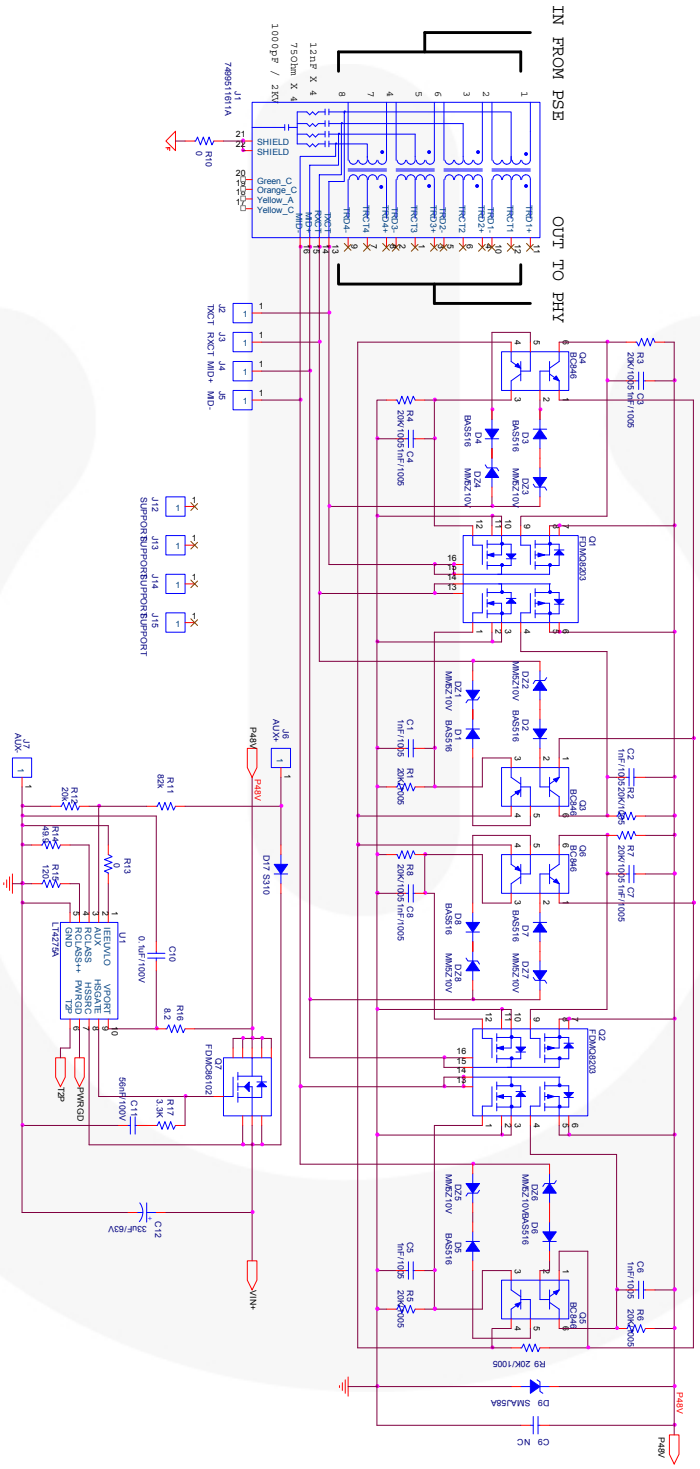


Figure 16. GreenBridge™ & PD controller Block Schematic

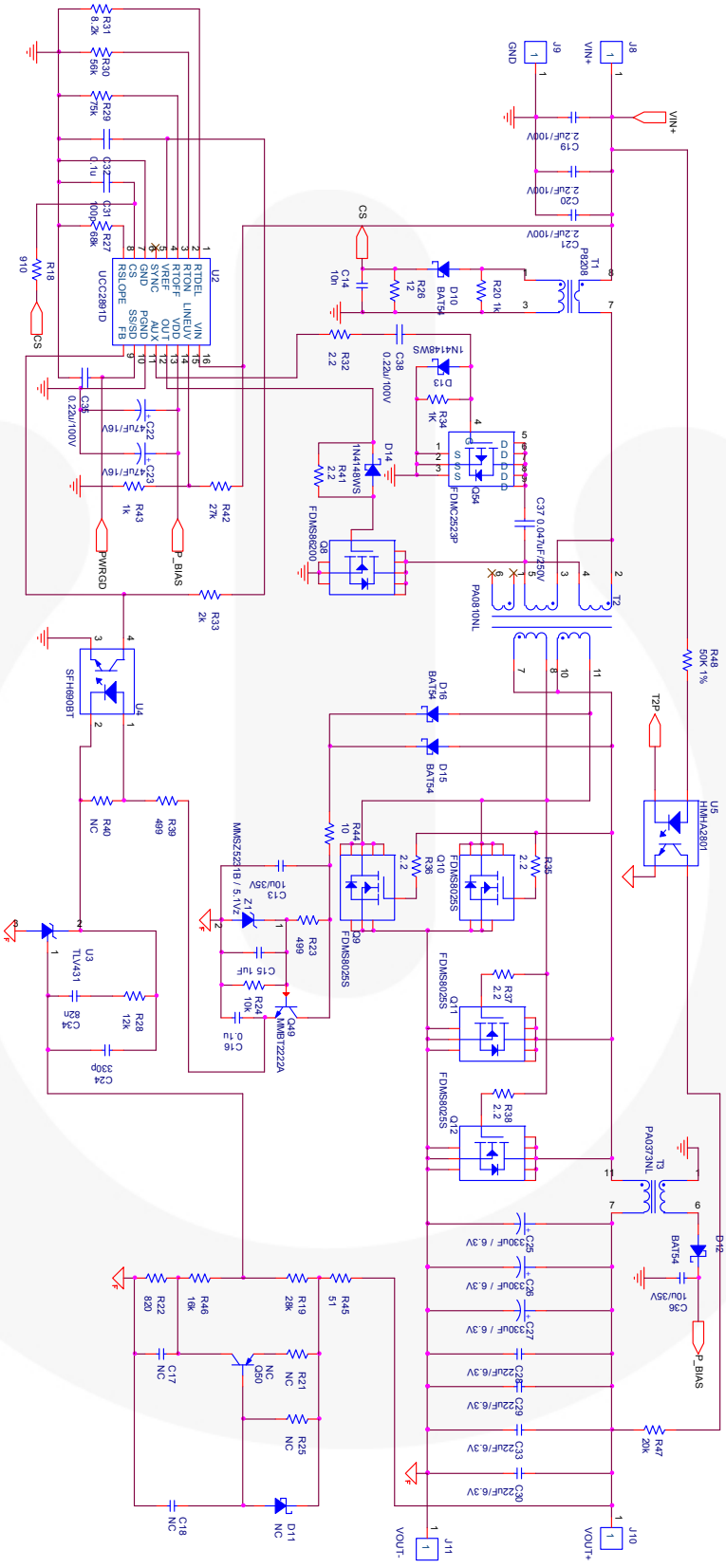


Figure 17. Active Clamp Forward DC-DC Block Schematic

8. Bill of Materials

#	Qty.	Reference	Part Name	Vendor	Comment
1	8	C1,C2,C3,C4,C5,C6,C7,C8	1 nF / 1005	Any	1 nF / 50 V / 1005
2	8	C9,D11,C17,C18, R21,R25,R40,Q50	NC		
3	1	C10	C2012X7R2A104K	TDK	0.1 µF / 100 V / 2012
4	1	C11	VJ0805Y563KXBAT	Vishay	56 nF 100 V / 2012
5	1	C12	63SXV33M	Sanyo	33 µF / 63 V / Alu
6	2	C13,C36	CL32A106KLULNNE	SAMSUNG	10µF / 35 V / 3225
7	1	C14	10 nF / 50 V	Any	10 nF / 50 V / 1608
8	1	C15	1 µF / 50 V	Any	1 µF / 50 V / 1608
9	2	C16,C32	0.1 µF / 50 V	Any	0.1 µF / 50 V / 1608
10	3	C19,C20,C21	GRM32ER72A225KA35L	MURATA	2.2 µF / 100 V / 3225
11	2	C22,C23	GRM32ER61C476ME15L	MURATA	47 µF /16V/3225
12	1	C24	330 pF / 50 V	Any	330 pF / 50 V / 1608
13	3	C25,C26,C27	T520D337M006ATE010	Kemet	330 µF / 6.3 V / Tantalum
14	4	C28,C29,C30,C33	C3216X5R0J226M	TDK	22 µF /6.3V/3216
15	1	C31	100 pF / 50 V	Any	100 pF / 50 V / 1608
16	1	C34	82 nF / 50 V	Any	82 nF /50 V / 1608
17	2	C35,C38	C0805C224K1RACTU	Kemet	220 nF /100 V / 2012
18	1	C37	GRM31CR72E473KW03L	MURATA	47 nF /250 V / 3210
19	8	DZ1,DZ2,DZ3,DZ4,DZ5,DZ6,DZ7,DZ8	MM5Z10V	Fairchild Semiconductor	10 V Zener Diode
20	8	D1,D2,D3,D4,D5,D6,D7,D8	BAS516	NXP Semiconductors	SW 75 V 250 mA HS
21	1	D9	SMAJ58A	Diodes	TVS diode
22	4	D10,D12,D15,D16	BAT54	Fairchild Semiconductor	BAT54
23	2	D13,D14	1N4148WS	Fairchild Semiconductor	1N4148WS
24	1	D17	S310	Fairchild Semiconductor	S310
25	1	J1	7499511611A	Wurth Electronics	RJ45 w/ Transformer
26	9	J2,J3,J4,J5,J6,J7,J8,J9,J10,J11	Test Pin	Any	3 mm
27	2	Q1,Q2	FDMQ8203	Fairchild Semiconductor	GreenBridge™ Quad MOSFET
28	4	Q3,Q4,Q5,Q6	BC846BPDW1T1G	ON Semiconductor	80 V Dual Complementary
29	1	Q7	FDMC86102	Fairchild Semiconductor	100 V 24 mΩ MOSFET
30	1	Q8	FDMS86200	Fairchild Semiconductor	150 V 18 mΩ MOSFET
31	4	Q9,Q10,Q11,Q12	FDMS8025S	Fairchild Semiconductor	30 V 2.8 mΩ MOSFET

#	Qty.	Reference	Part Name	Vendor	Comment
32	1	Q49	MMBT2222A	Fairchild Semiconductor	NPN Transistor
33	1	Q54	FDMC2523P	Fairchild Semiconductor	(-)150 V 1.5 Ω MOSFET
34	9	R1,R2,R3,R4,R5,R6,R7,R8,R9	20 kΩ / 1005	Any	20 kΩ / 1005
35	2	R10,R13	0 Ω / 1608	Any	0 Ω / 1608
36	1	R11	82 kΩ / 1608	Any	82 kΩ / 1608
37	2	R12,R47	20 kΩ / 1608	Any	20 kΩ / 1608
38	1	R14	49.9 Ω / 1608	Any	49.9 Ω / 1608
39	1	R15	120 Ω / 1608	Any	120 Ω / 1608
40	1	R16	8.2 Ω / 1608	Any	8.2 Ω / 1608
41	1	R17	3.3 kΩ / 1608	Any	3.3 kΩ / 1608
42	1	R18	910 Ω / 1608	Any	910 Ω / 1608
43	1	R19	28 kΩ / 1608	Any	28 kΩ / 1608
44	3	R20,R34,R43	1 kΩ / 1608	Any	1 kΩ / 1608
45	1	R22	820 Ω / 1608	Any	820 Ω / 1608
46	2	R23,R39	499 Ω / 1608	Any	499 Ω / 1608
47	1	R24	10 kΩ / 1608	Any	10 kΩ / 1608
48	1	R26	12 Ω / 1608	Any	12 Ω / 1608
49	1	R27	68 kΩ / 1608	Any	68 kΩ / 1608
50	1	R28	12 kΩ / 1608	Any	12 kΩ / 1608
51	1	R29	75 kΩ / 1608	Any	75 kΩ / 1608
52	1	R30	56 kΩ / 1608	Any	56 kΩ / 1608
53	1	R31	8.2 kΩ / 1608	Any	8.2 kΩ / 1608
54	6	R32,R35,R36,R37,R38,R41	2.2 Ω / 1608	Any	2.2 Ω / 1608
55	1	R33	2 kΩ / 1608	Any	2 kΩ / 1608
56	1	R42	27 kΩ / 1608	Any	27 kΩ / 1608
57	1	R44	10 Ω / 1608	Any	10 Ω / 1608
58	1	R45	51 Ω / 1608	Any	51 Ω / 1608
59	1	R46	16 kΩ / 1608	Any	16 kΩ / 1608
60	1	R48	50 kΩ	Any	50 kΩ
61	1	T1	P8208NL	Pulse	CURRENT SENSE 2000 µH
62	1	T2	PA0810NL	Pulse	Inductor
63	1	T3	PA0373NL	Pulse	Transformer
64	1	U1	LT4275	Linear	PoE++ PD Controller
65	1	U2	UCC2891PW	Texas Instruments	PWM Controller
66	1	U3	TLV431	Texas Instruments	Shunt Regulator
67	1	U4	SFH690BT	Vishay Semiconductors	Phototransistor
68	1	U5	HMHA2801	Fairchild Semiconductor	Opto-coupler
69	1	Z1	MMSZ5231B 5.1Vz	Fairchild Semiconductor	MMSZ5231B 5.1Vz

9. Revision History

Rev.	Date	Description
1.0.0	September 2013	Initial Release
1.0.1	November 2013	Fixed typo table 4 VOUT to VIN

WARNING AND DISCLAIMER

Replace components on the Evaluation Board only with those parts shown on the parts list (or Bill of Materials) in the Users' Guide. Contact an authorized Fairchild representative with any questions.

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